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Self-directed learning - fashionable among all first-year African engineering students?

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ABSTRACT: Self-directed learning requires students to take ownership of their own learning, to become agents in the learning process, to engage in active learning and to enjoy the satisfaction of learning. This may be achieved in a project-based learning module, where students need to demonstrate a number of graduate attributes. However, it has been reported that undergraduate students struggle with self-directed and project-based learning. The research question, therefore, arises *Is self-directed learning fashionable among all undergraduate first-year African engineering students who enrol for a project-based learning module in South Africa?* A descriptive case study is used, where quantitative data is derived from the Williamson self-rating scale of self-directed learning (SRSSDL). Top responses suggest that students are aware of their responsibility for their own learning and that they should decide on their own learning strategies. One of the lowest responses suggests that students are finding it challenging to pursue learning among different cultures. Results further indicate that two out of every three students rated themselves as high-level self-directed learners, with 88% of these students successfully completing the module. It is recommended to educate first-time entering engineering students in how to successfully deal with cultural diversities, which is a requirement of self-directed learning.

Keywords: Individual learning, problem-based learning, project-based learning, graduate attributes

INTRODUCTION

Fashion is not something that exists in dresses only. Fashion is in the sky, in the street, fashion has to do with ideas, the way we live, what is happening [1]. These words, by French designer Coco Chanel, well emphasise that fashion is not limited to new styles of dress and grooming, but also exists in ideas and in current affairs. Project-based learning (PjBL) has been a current affair in education for some time now, with more institutions of higher learning recognising its many benefits in helping students to achieve key graduate attributes demanded by industry today.

PjBL is defined as an important method, which is used to make students acquire necessary knowledge, vital skills and citizenship values for the 21st Century, and includes portfolios, performance assessments and written reports [2]. Donnelly and Fitzmaurice define PjBL as an *…individual or group activity that goes on over a period of time, resulting in a product, presentation, or performance* [2]. PjBL is a strategy that enhances innovative and high-quality teaching and learning within a complex task-based environment by producing an artefact or end product [3]. On the other hand, problem-based learning may occur within one module or even within one practical experiment covered in a module within a limited period of time [4]. So, while there are subtle differences between PjBL and problem-based learning, it may be fair to say that the one includes aspects of the other, as solving a problem does not necessarily include executing a project in the formal sense [5]. It has been reported that PjBL may enhance students' self-directed learning (SDL) [6], and enable them to demonstrate a number of graduate attributes currently mandated by the International Engineering Alliance (IEA) [7].

However, it has been reported that some students struggle to adapt to PjBL and problem-based learning. This has been documented in the field of automation [8], engineering [9], experiential learning [10], geography [11] and nursing [12]. Challenges include struggling with the unfamiliarity of the new environment, with teamwork, with communication, with interpersonal skills, with deadlines and in missing traditional classroom lectures. It has also been reported that undergraduate students struggle with SDL [13], partly due to social changes and the increasing demands on students [14]. The research question, therefore, arises *Is SDL fashionable among all undergraduate first-year African engineering students who enrol for a PjBL module in South Africa?*

The purpose of this article is to present the results of the Williamson self-rating scale of self-directed learning (SRSSDL), which was completed by undergraduate African engineering students in 2015, 2016 and 2017.

This SRSSDL was originally developed to assess SDL behaviour that is different from the simple measuring of perceptions and readiness for SDL [15]. This article firstly presents a brief review of SDL and, then covers some of the main rating scales, which have been developed for it. The context of this study is then given, along with the research methodology, which features a descriptive case study with quantitative data. Results and discussions occur simultaneously followed by the conclusions.

SELF-DIRECTED LEARNING

Some researchers trace the concept of SDL back to Lindeman in 1926 [16], while others state that it was first discussed by Tough in 1966 [17]. Still others argue that the concept of SDL was first used in the process of learning by Dewey in 1918 and expanded to the education process after being defined as a learning skill by Knowles in 1975 [18]. However, what seems to be acceptable to the majority of researchers is that SDL is neither new nor innovative, being used for decades to refer to the ability of students to direct their own learning. One definition of SDL is that it is …*an active constructive process whereby learners set goals for their learning and monitor, regulate, and control their cognition, motivation and behavior guided and constrained by their goals and the contextual features of their environment* [19].

Another definition states …*SDL is a process by which individuals set goals, locate resources, choose the method and evaluate progress through critical reflection* [20]. It has also been defined …*as learning that occurs as a part of an adults everyday life that is self-directed and does not depend on a classroom or an instructor* [21]. The most referenced definition is that by Knowles that states that SDL is a …*process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material learning resources, choosing and implementing the most appropriate learning strategy and evaluating the results* [22]. However, one can discern from the many definitions that SDL requires students to take ownership (responsibility) of their own learning, to become agents (act independently) in the learning process, to engage in active learning and to enjoy the satisfaction of learning.

A number of scales have been proposed with regard to determining SDL within students. These included Guglielmino's [23] readiness scale, Deng's [24] Chinese version of Guglielmino's instrument, Aydede and Kesercioğlu's [25] scale, Ho's [26] ability scale, Fisher, King and Tague's [27] readiness scale, and Williamson's [28] self-rating scale. Guglielmino's scale was developed to comprehend the influences of the individual characteristics, skills and motivations of self-directed learners, and contained 58 items that are rated on a 5-point Likert scale. Aydede and Kesercioğlu's scale was aimed at a course in science and technology and comprised 25 items focusing on planning and confidence within SDL. The ability scale of Ho was geared towards contract learning and featured 14 items covering planning, self-assessment and the search for human resources. Fisher, King and Tague's scale focused on nursing education, featuring 41 items comprising self-management, learning eagerness and self-control. Williamson's SRSSDL was used in higher education to determine, which skills would be required for life-long learners. It features 58 items (each with a 5-point Likert scale) covering five sub-factors; namely, awareness, learning strategies, learning activities, assessment and interpersonal skills.

Awareness relates to students understanding the factors that contribute to SDL. Learning strategies requires students to select specific strategies, which they currently use that are directly linked to SDL. Learning activities requires students to select specific activities, which they currently use that are directly linked to SDL. Evaluation helps to reveal specific student attributes with regard to how they monitor their individual learning. Interpersonal skills list specific skills, which students need to demonstrate if they are to successfully engage in SDL. Williamson's SRSSDL is usually divided into three categories; namely, low-level SDL (students who score less than 140), moderate-level SDL (students who score between 140 and 220) and high-level SDL (students who score more than 220).

STUDY CONTEXT

Professional Practice I, better known as FIAP 172 by students and academics at North West University (NWU) in South Africa, is a compulsory module in the Bachelors engineering qualification (termed the BEng degree) for all undergraduate engineering students at NWU [29]. It is offered over the course of one year, with the syllabus split across two semesters, which are each approximately 14 weeks in duration. Students have to accumulate 628 credits in this 4-year degree, where the first-year comprises 156 credits, the second-year 180 credits, the third-year 156 credits and the fourth-year 136 credits. Engineering students obtain 24 credits, when they successfully complete FIAP 172, indicating that they devoted 240 notional hours to this module. The aim of FIAP 172 is to give engineering students the opportunity to develop important management and construction skills, as it involves much group work, where imaginary companies are formed with the goal of designing and constructing working projects to meet the needs of actual clients (be it industry, commercial enterprises or government departments). Some of these projects include a working hovercraft, a pet-dipping station and a recycling machine, all designed and developed by first-year African engineering students.

Registered first-year African engineering students are initially required to complete a practical workshop induction programme (offered during March) before engaging with the aim of the module. This requires students to attend three different practical sessions, each a total of eight-hours in duration. This induction covers aspects relating to safety, electrical motor operations, welding, fitter and turning practice, and general electrical principles. This empowers students with the required theoretical knowledge, which they will need to apply, when engaging with the aim of the module. This aligns with research by Biggs and Tang who state that quantitative stages of learning (knowledge or theory) occur first, followed by qualitative stages of learning (application or practice) [30]. It also follows the learning cycle of Kolb (concrete experience, reflective observation, abstract conceptualisation and active experimentation) [31], and the alternative framework for developing performance objectives devised by Gagné (verbal information, intellectual skills, cognitive strategies, motor skills and attitudes) [32]. Students are rotated among the three practical sessions, as the workshops are not large enough to accommodate all the registered students at the same time. An indemnity form is furthermore signed by the students, thereby releasing the University from any legal action that may arise due to student negligence. During this time, the facilitator meets with potential clients from industry, commerce and government departments to ascertain their needs or problems, which need to be solved.

A list of possible projects from actual clients is then shared with groups made up of six students each, who need to select three possible ones and prepare a PowerPoint presentation for each one in which they detail what they think would be required to successfully complete the project. The facilitator then assigns a specific project to a group based on their level of understanding of that project as demonstrated in their presentation. A concept design, detailed design and budget must then be submitted (end of April). Detailed designs of the project are required using CAD software at the end of May, before students enter the official mid-year examination and vacation period (June through July). Students physically work on their project for about two months, with a final evaluation at the end of September. An exhibition in October makes their completed project public knowledge to the actual clients, industry, commercial and government representatives that are present. Regular communication between the facilitator and student groups occur via the institutions learning management system, which is built on the SAKAI platform [33].

This module covers the majority of graduate attributes (GA) prescribed by the IEA [34]. Engineering knowledge (GA1) is demonstrated, when students recall basic fundamental theories in the design (GA3) of their project, such as Kirchhoff's voltage and current laws to determine the battery size required to power a hovercraft for 10 minutes. Problem analysis (GA2) is demonstrated, when students need to overcome a hurdle or challenge in their design, often requiring investigation (GA4), modern tool usage (GA5) and teamwork (GA9). For example, students may need to electronically measure the distance between two objects in a recycling machine. Investigation and research using the Internet may lead them to use an ultrasonic sensor, while teamwork will enable them to position it in the best possible location for optimum measurements. Here communication (GA10) is also essential, as students need to discuss the steps that need to be taken to complete the project.

Project management and finance (GA11) is the foremost attribute acquired by these students, who need to manage meetings, monitor the budget, purchase required materials and evaluate the progress of the project. Ethics (GA8) and sustainability (GA7) should also be demonstrated in the appropriate expenditure of funds and the use of recycle material. During the public presentation, students engage with society (GA6) as they highlight the operation and benefits of their working project. It is further hoped that the entire module will create awareness among these first-year engineering students about the importance of entrepreneurship, which requires life-long learning (GA12). This is a true PjBL module that actively engages students in their learning by giving them the opportunity to construct knowledge and a product as part of a team, which is really a simulation of a common work-force experience [35].

RESEARCH METHODOLOGY

A descriptive case study, with quantitative data, is used in this research as it describes a situation (student ratings of their SDL) within a real-life context (students engaging with PjBL within FIAP 172). Yin describes three types of case studies, being exploratory (examines a situation, where an intervention produces no single clear result), descriptive (describes a situation within a real-life context) and multiple case studies (discovers differences between/within cases) [36]. Statistical analysis and quantitative data is useful in making comparisons across relatively large numbers of people, events or objects [37]. In this study, the target population is relatively large (n = 1,058) as it encompasses all undergraduate registered students for FIAP 172 over a 3-year period, thereby negating the use of a sampling technique. Quantitative data is used to highlight the average student self-rating scores obtained from the Williamson SRSSDL for 2015, 2016 and 2017. This SRSSDL was completed by students during the induction programme held in March. These results cover five sections; namely, awareness, learning strategies, learning activities, evaluation and interpersonal skills.

Quantitative data also includes the final grades awarded to these students, which are presented using descriptive statistics (standard deviation, variance, kurtosis, skewness, mode and median). These final grades are furthermore correlated to the total scores from the Williamson SRSSDL (maximum score of 290 possible). This scale features 58 questions, with 12 questions dedicated to each of the five sections. Each question features a 5-point Likert scale (1 = never; 2 = seldom; 3 = sometimes; 4 = often; and 5 = always) designed to probe student's perception of themselves with regard to specific statements used in each of the five sections. The average value for each question is then calculated for each calendar year and portrayed on a bar graph. The standard deviation and variance for each question is calculated in MS Excel, so as to determine the top 10% and bottom 10% responses, along with the proximity of the responses. The skewness is used to see if the distribution is concentrated more on the left or on the right, while the kurtosis indicates whether the distribution features a peaked or flat response. The mode (value that occurs most often) and median (value with half the grades above and below it) values may also be used to indicate the type of distribution.

RESULTS AND DISCUSSIONS

A total sample size of 1,058 exists (2015 = 337, 2016 = 333 and 2017 = 388), where the majority of students are male (on average 4.5 times more than females). Males tend to dominate engineering in South Africa [38] as is the case in the rest of the world [39]. The majority of students were 18 years old, which validates them as first-year undergraduate students who have just completed their secondary or high school career (average age for Grade 12 learners in South Africa is 18 years [40]).

The majority of students are enrolling for this module for the first time, as they indicated that they are in their first-year of their higher educational studies. A small minority of students are repeating the module for the second or third time, as they could not successfully complete it at their first attempt. This may be linked to research by Henry et al who found that PjBL presented significant challenges to some undergraduate engineering students; in particular, the students missed traditional faculty lectures and struggled to work successfully in groups [41].

Figures 1 through 5 present the student responses (average values shown) to each of the 12 questions for the five sections making up the Williamson SRSSDL. The average standard deviation value is also shown for questions that meet a specific condition. MS Excel has a conditional formatting rule, where the top 10% and bottom 10% values of a given data stream may be highlighted. This was used to highlight the top 10% and bottom 10% average values for all 58 questions. This means that five questions with the highest average values (many students selecting often (4 points) and always (5 points) from the 5-point Likert scale) and five questions with the lowest average values (more students selecting never (1 point) and seldom (2 points)) would be highlighted in red and yellow, respectively. However, this same conditional format is applied to the standard deviation of the responses. When the conditional formatting rule highlights both average values and standard deviations for a specific question, then their standard deviation is shown on the bar graph. This was determined for 8 questions (4 with the highest average values and 4 with the lowest average values for all three years).

Figure 1 reveals two questions that fell within the top 10% of the 58 items, having a low average standard deviation (Ave. Std. Dev.). A high percentage of respondents are aware that they are responsible for their own learning (Q5 with 0.52) and that they are responsible for identifying areas of deficiency in their learning (Q6 with 0.65). Figure 2 shows two questions that fell within the top 10% and two that fell within the bottom 10% of the 58 items. A high percentage of respondents indicated that they possess two key learning strategies that are linked to SDL; namely, *I regard problems as challenges* (Q8 with 0.73) and *I am able to decide my own learning strategy* (Q12 with 0.71).

Problem-solving is one of the GA of the IEA that all engineering students should be able to demonstrate [34]. However, two learning strategies exist with low average points (less than three) and high average standard deviations (above one). This indicates that students are divided on the use of these strategies, which focuses on role play as a useful method for complex learning (Q3 with 1.10) and the use of concept mapping as an effective method of learning (Q10 with 1.07). This is in contrast to research in India that shows that engineering students love role-play [42], while research in England confirms that engineering students do not consider concept mapping of greatest importance as a learning strategy [43].

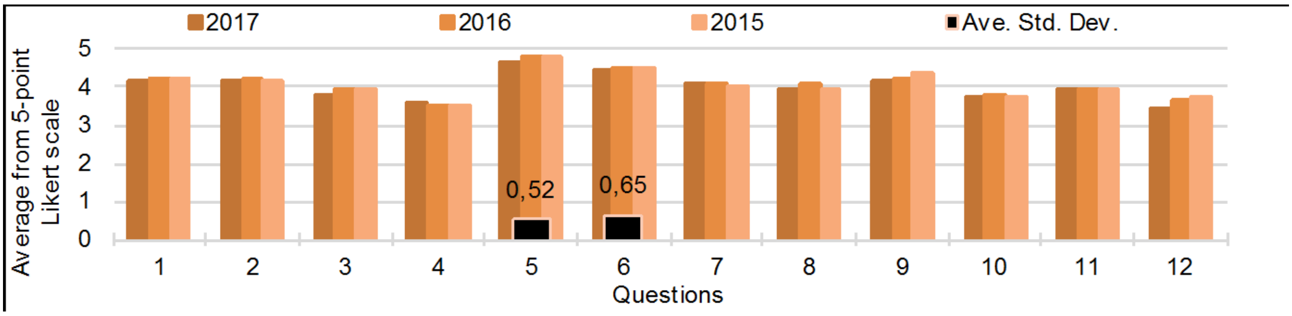

Figure 1: 12-questions from the Williamson SRSSDL regarding awareness.

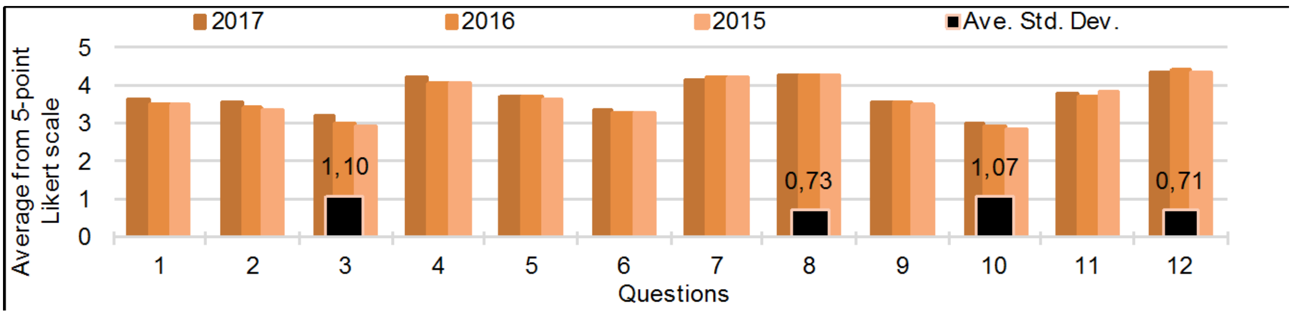

Figure 2: 12-questions from the Williamson SRSSDL regarding learning strategies.

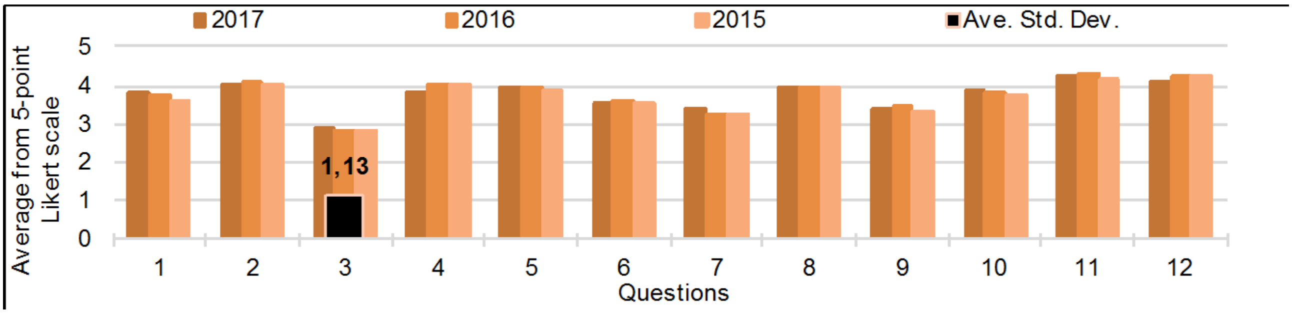

Figure 3: 12-questions from the Williamson SRSSDL regarding learning activities.

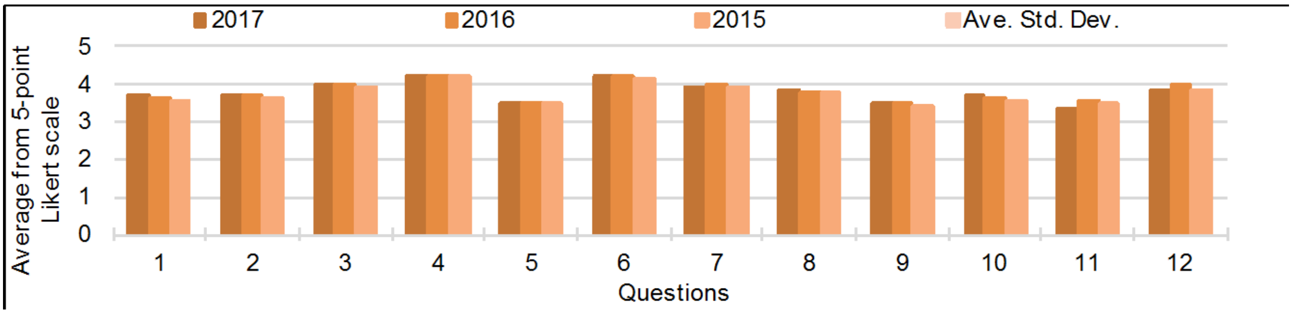

Figure 4: 12-questions from the Williamson SRSSDL regarding evaluation.

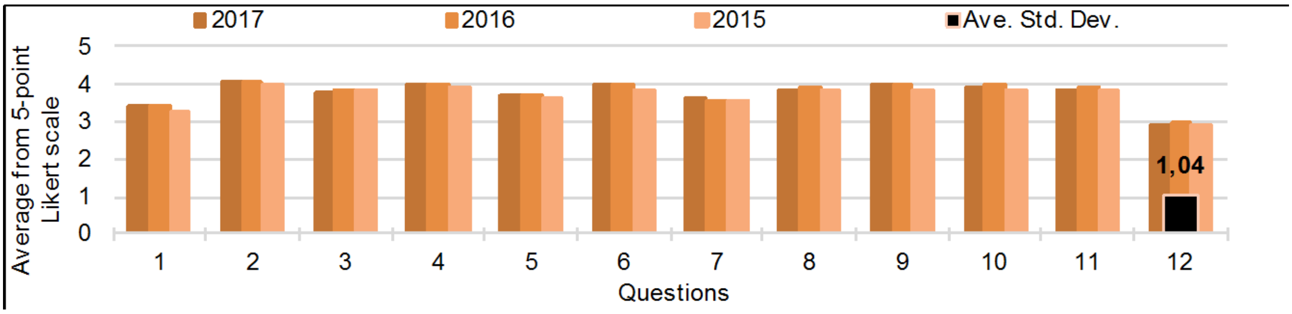

Figure 5: 12-questions from the Williamson SRSSDL regarding interpersonal skills.

Figure 3 indicates one question that fell within the bottom 10% of the 58 items (average value from the 5-point Likert scale less than 3), having a high average standard deviation. Respondents have mixed feelings about using concept mapping as a useful method of comprehending a wide range of information (Q3 with 1.13). This corresponds to the result for question 10 (Q10 with 1.07) in Figure 2. No questions under evaluation (Figure 4) fell within the top 10% or bottom 10% of the 58 items. This indicates that students are in relative agreement on the beneficial use of self-assessments, peer-assessments, reflective practice and critical feedback. Figure 5 highlights one last question, which falls under the bottom 10% of the 58 items (average value for the three years below 3, from the 5-point Likert scale). This question states *I find it challenging to pursue learning in a culturally diverse milieu*. Respondents seem to find it difficult to learn within an environment characterised by many cultures, which is confirmed by Rodgers and Tennison who indicate that many first-year students struggle with culture shock, homesickness and other issues [44].

Table 1 portrays the three student rating levels, as obtained from the Williamson SRSSDL. The majority of first-year undergraduate African engineering students rated themselves as high-level SDL students (average of 68% for the 3-year period). More females than males rated themselves as high-level SDL students. Furthermore, more moderate-level rated SDL students are likely to fail the PjBL module (18% on average) as compared to high-level rated SDL students (12% on average). According to Conn, individuals with a higher level of readiness for SDL are more likely to engage in actual SDL activities [45]. This, in turn, may lead to improved learning outcomes and student satisfaction [46].

Table 1: Student rating levels derived from the Williamson SRSSDL.

Year	Low-level (<140)	Moderate-level (140-220)	High-level (>220)	Males - high-level	Females - high-level	Moderate level fail	High-level fail
2015	0%	35%	65%	64%	73%	15%	10%
2016	0%	27%	73%	70%	86%	20%	11%
2017	0%	34%	66%	65%	73%	20%	16%
Average	0%	32%	68%	66%	77%	18%	12%

Table 2 illustrates the descriptive statistics of the final grades along with the Pearson correlation values and *p*-values. This correlation and significance test was done between the total score from the SRSSDL and the final student grades awarded at the end of each calendar year. No statistically significant relationship exists between the final grades of the students and their SDL rating score. This has been confirmed by other research [47]. The standard deviation is relatively constant, as is the kurtosis and skewness values, which indicate that a larger number of students lie above the median value. What is concerning is the mode value for 2015 and 2016 (most occurring final grade was 0). This suggests that a number of students registered for the module, completed the induction programme and then dropped out of the module.

Table 2: Correlations and descriptive statistics of the final grades of the students in FIAP 172.

Year	Sample	Pearson	*p*-value	Pass	SD	Variance	Kurtosis	Skewness	Mode	Median
2015	337	0.043	0.428	88%	24	576	1.53	-1.23	0	71
2016	333	0.065	0.231	87%	25	607	1.88	-1.61	0	70
2017	388	0.085	0.094	83%	19	368	1.38	-1.21	50	60

CONCLUSIONS

The purpose of this article was to present the results of Williamson SRSSDL, which was completed by 1,058 first-year undergraduate African engineering students between 2015 and 2017. The top four responses with the lowest standard deviation relate to students being aware of their responsibility for their own learning, that they are responsible for identifying areas of deficiency in their learning, that they regard problems as challenges and that they are able to decide on their own learning strategies. The lowest four responses with the highest standard deviation relate to students not currently using role play or concept mapping, while finding it challenging to pursue learning among different cultures.

Results also indicate that two out of every three students rated themselves as high-level self-directed learners, with a higher percentage of females rating themselves as high-level self-directed learners as compared to the males. A higher percentage of moderate-level self-directed learners failed the PjBL module as compared to high-level self-directed learners. No statistically significant relationship was found between the individual rating scores of the students and their final grades awarded at the end of the year. Based on these results, is it plausible to conclude that SDL is fashionable among all undergraduate first-year African engineering students who enrol for a PjBL module in South Africa? The answer is no. Adopting role play and concept mapping, while overcoming cultural diversities stand out as key challenges that some students will have to contend with, if SDL is to be fashionable among all undergraduate students.

If cultural diversities continue to be a challenge, then some students may struggle to successfully demonstrate the GA of teamwork, communication and engagement with society. Furthermore, on average, 32% of the students rated themselves as moderate-level self-directed learners. This suggests that SDL is not really fashionable among 338 students (0.32 x 1,058), who would have otherwise rated themselves as high-level self-directed learners. A key recommendation is to educate first-time entering engineering students in the effective use of concept mapping, while creating awareness of how to cope with cultural diversities, which are requirements for SDL. PjBL may continue to be a current affair in higher education, where students will need to engage more with SDL in order to demonstrate key GA linked to the module. This may require more students to adopt SDL as they themselves becoming fashionable with current affairs in higher education.

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BIOGRAPHY

Arthur James Swart completed his Master's in Education in 2007 and his Doctoral in Electrical Engineering in 2011. He is currently an Associate Professor at the Central University of Technology, Bloemfontein, South Africa, where he mentors staff members regarding the scholarship of teaching and learning. His educational research focuses on the effective use of educational technology to help students fuse their theory and practice. His field discipline research focuses on electronic communication and solar energy. His research collaboration network includes the North-West University, the Cape Peninsula University of Technology, the Vaal University of Technology and the University of South Africa. James has published over 100 conference papers and journal articles within the fields of electrical engineering and engineering education. He has a passion for life-long learning and holds the motto that *consistency is often a mark of quality*.